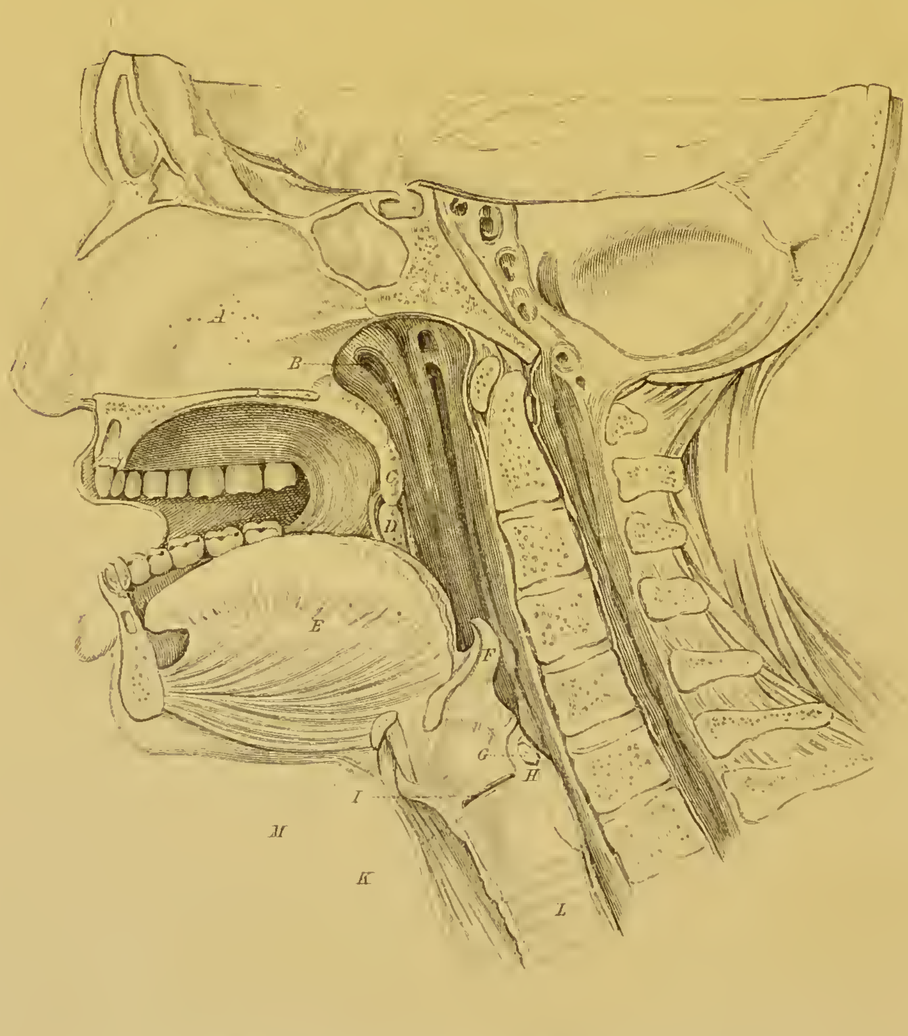
IMPEDIMENTS OF SPEECH

BISHOP.

Fig. 1



A MESIAL SECTION OF THE VOCAL ORGANS

A Septum Narium
B Eustachian Tube
C Uvula
D Tonsil of Right Side
E Section of Tongue
F Epiglottis

G Section of Arytenoid Muscle
H Base of Arytenoid Cartilage
I Right Ventricle of Larynx
K Right Chorda Vocalis
L Internal Surface of Trachea
M Section of Os Hyoides

ON THE

CAUSES AND TREATMENT

OF

IMPEDIMENTS OF SPEECH;

INCLUDING THE THEORY OF

ARTICULATE SOUNDS,

AND ON THE CONSTRUCTION OF

HEARING AND SPEAKING INSTRUMENTS.

BY

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PREFACE.

DURING the past and the present century great advances have been made in the science of Acoustics, which has been applied with considerable success to the functions of the vocal organs in man. The Author has therefore thought it desirable at this time to give a brief exposition of the Physiology and Pathology of the articulating organs.

Those who have studied the treatises of Euler, Poisson, Chladni, Biot, Sir John Herschel, and the Rev. Mr. Willis, must not only have derived a tolerably correct opinion of the present state of acoustic science, but must also perceive the difficulties with which the subject of vibrating membranes is still encompassed.

The first part of this work is intended to supply the data necessary for the study of the pathological condition of the organs of articulation. It is shown that the Physiology of the subject terminates at

that point where the Orthoëpy begins, and that the boundaries which separate these branches of knowledge are clearly defined.

Of the articulating organs, as of all others, the pathology is necessarily derived from the physiology. In the treatment of their disorders, however, we possess advantages much greater than in the disorders of many other parts of the body, of which the normal functions are less understood, and the pathological conditions less obvious to the senses. Hence, our success in the treatment of the defective use of the vocal organs is considerably greater, and it is hoped that, in the following pages, some of the points connected with this difficult subject are satisfactorily cleared up. A rational plan of treatment appears to be the more necessary because, when cases of this kind formerly presented themselves, surgeons were not in possession of any correct theory on the subject; the want of which has encouraged unqualified empirics to occupy the vacant ground, with manifest discredit to the profession, and detriment to the public.

It was after the author had occupied his leisure hours during several years in studying the physiology of the human voice, as a subject of abstract

research, that his attention was forcibly drawn to its pathology, by the surgical treatment of impediments of speech proposed by Dieffenbach, and others. The author has ever been at a loss to comprehend how a mechanism, so elaborate and perfect in its normal state as that of the vocal organs, could be expected to perform its office after mutilation. This question he leaves to the disciples of Dieffenbach to answer; but is satisfied in his own mind that the course they have pursued has resulted from their imperfect knowledge of the physiology of these organs, leading them in many cases to mistake functional derangement for organic defect.

38, *Bernard-street, Russell-square,*
March 30, 1851.

ON THE CONSTRUCTION

OF

HEARING AND SPEAKING INSTRUMENTS.

It does not appear that any attention has of late been paid to the acoustic laws which should regulate the construction of Hearing-trumpets, and the result is, as might naturally be expected, that many empirical methods have been employed, and many extravagant notions of their value entertained, the fallacy of which, however, a slight investigation would be sufficient to demonstrate.

It must have struck the most superficial inquirer into these subjects, that the instruments now in use answer the purpose of the patient very well as long as the person with whom he is in conversation keeps his mouth within a very small distance of the external aperture of the instrument; but that, whenever the

speaker removes a few feet from the aperture, his voice becomes totally inaudible by the deaf person whom he addresses.

To find a remedy for these defects, so as to enable a deaf person to hear at any other distance sounds which are audible by him with an ear-trumpet of a given aperture at a given distance from the speaker, is the problem we propose to investigate. We know by the theory of acoustics, that a sound diminishes in intensity in proportion to the square of the distance of the organs of hearing from the origin of the sound; and we also know from geometry, that the areas of similar figures are as the squares of their corresponding lines. From these acoustic and geometric laws we can easily determine the area of an ear instrument, when the distance between the speaker and the hearer is altered. Let A be the diameter of the aperture of the instrument through which the patient can hear a person speaking at the distance D from the external aperture, then, at any other distance mD, the intensity of the sound at the aperture will, by the first of the above-mentioned laws, be to its intensity at the original distance D, as $D^2 : m^2D^2$, or as $1 : m^2$. From this calculation, as well as from experience, it is clear that the same instrument cannot collect the same amount of sound at different distances; and, since the quantity of sound collected depends upon the area of the aperture, we must, in order to collect the same amount of sound, vary that area in exactly the same proportion as the intensity of the sound has been changed; and therefore

by the second law, the diameter of the aperture must become mA, for the new area will then be to the original area : : $m^2A^2 : A^2$, or as $m^2 : 1$; in other words, in whatever proportion we diminish or increase the intensity of the sound by altering the distance, in just the same proportion we must inerease or diminish the area of the aperture, and therefore the amount of sound eollected, by altering its diameter. If, for instance, a person ean by means of an instrument with an aperture, of whieh the diameter is 2 inehes, hear distinetly one speaking at 3 inehes distance from the aperture, and wishes to have a similar instrument enabling him to hear equally well the same person speaking at a distance of 3 feet, the new instrument must have a diameter of 2 feet, sinee the voiee of the speaker, when removed 3 feet, will only have $\frac{1}{144}$th part of its effeet when at 3 inches ; and eonsequently the new instrument must be able to eollect 144 times as mueh of this weakened sound as the former one would do at the same distanee, *i. e.* the diameter of the aperture must be 24 inches, which, being 12 times as long, will give an area 144 times as large as it was before.

From these laws we can easily conelude how diffieult and inconvenient it would be to construct instruments with an aperture large enough to collect sounds of suffieient intensity at distanees exeeeding 2 or 3 feet. This diffieulty is, however, in some measure obviated by constructing an instrument in the form of an elongated and flexible eylindrical tube, sueh as those now made of gutta pereha. The advantage of

this plan consists in the facility which it affords of transferring the external aperture to different distances between the speaker and hearer. Now the intensity of sound appears not to be sensibly diminished, within moderate distances, when the air passes through a straight and rigid tube*; but gutta percha, which on account of its flexibility is most convenient for actual use, is, owing to this very quality, ill-adapted to transmit sound without loss, as is found to be the case in public offices, where the voice has to be conveyed to considerable distances. Another disadvantage attending the use of the elastic ear-tube by deaf persons, arises from the necessity of carrying a long coil of the tube, in order to converse with persons even across an ordinary table. Now, although some disadvantage attends every artificial method of improving the sense of hearing, it must be borne in mind that the same objection applies to the instruments used for assisting the sight: spectacles and telescopes require to have their focal lengths varied, when the objects to be seen are at various distances.

It was not until Lambert undertook the task of rigidly examining the principles of speaking- and hearing-trumpets, that any very precise notions of their laws had been attained †. He has gone very fully into the subject, and after a thorough mathematical investigation, principally devoted to speaking instruments, which will be more particularly noticed

* Biot, vol. i. p. 316.

† Mémoires de l'Académie Royale des Sciences. Berlin, 1763.

hereafter, he came to the conclusion that the paraboloid is the best form for a hearing-trumpet ; but, since his conclusion is based upon the fact of the origin of the sound being so distant that all the "phonic rays," as he terms them, enter the trumpet nearly parallel to the axis, and are therefore collected in its focus, where, or near to which, the ear is to be placed, it is evident that his reasoning does not apply to instruments intended to assist ordinary conversation with deaf persons. Lambert, however, shows that hearing-trumpets may be conoids, which is the form he demonstrates to be the best adapted for speaking-trumpets ; proving that the same laws regulate both, and that owing to the size of the mouth-piece in the latter being much greater than the orifice for the ear in the former, the speaking- must be proportionally larger than the hearing-trumpet.

Assuming the conoid to be the most practicable form of the hearing-trumpet, we will now, without giving the details of the philosophical reasoning, state the results for the instruction of instrument-makers.

Suppose ACB to be a section of the conoid through the axis, $Ce=\frac{1}{2}AB=AE$ to be the distance of the orifice of the ear from the apex of the cone, *ed* perpendicular to the axis is the diameter of the orifice, which may be taken as $\frac{1}{3}$rd of an inch.

Then if $\phi=$half the angle of the cone, $CA : Ce :: 1 : \sin\phi$, and since $Ce \sin\phi = \frac{1}{6}$, $Ce=\frac{1}{6\sin\phi}$ and

$CA = \frac{1}{6 \sin^2 \phi}$, then A$e$, the length of the tube, $= CA - Ce$. By this formula we determine either the length of the tube of a given angular aperture, or the proper angle to be given to a tube of any required length.

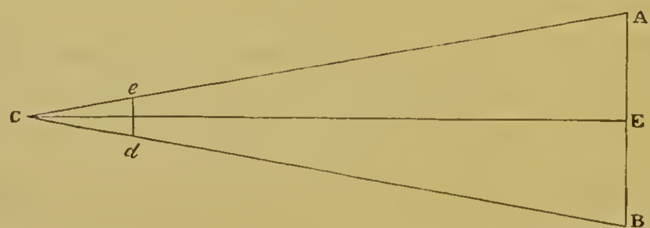
Let it be proposed, for instance, to make an instrument to enable a person to hear at 10 times the distance at which he can hear without it. We know from what has preceded that the area of the aperture of the instrument must be 100 times as large as the orifice of the ear, and consequently that the semi-diameter of the instrument must be 10 times that of the ear, *i. e.* $Ce = \frac{10}{6} = 1\frac{2}{3}$ inch $= \frac{1}{6 \sin \phi}$, whence

$$\sin \phi = \frac{1}{10}, \text{ and } \phi = 5° \, 44' \, 21'',$$

and the angle of the cone $= 2\phi = 11° \, 28' \, 42''$,

$$CA = \frac{1}{6 \sin^2 \phi} = \frac{100}{6} = 16\tfrac{2}{3} \text{ inches},$$

and Ae, the length of the tube, $= CA - Ce = 15$ inches.



To take another instance, let the distance at which a very deaf person can hear a sound of a given intensity be only 1 inch, and let it be required to make an

ear-trumpet to enable him to hear at 36 inches, then will

$$Ce = \frac{36}{6} = 6 \text{ inches} = \frac{1}{6 \sin \phi},$$

$$\text{whence } \sin \phi = \frac{1}{36},$$

$$\phi = 1^\circ\, 35'\, 33''. \quad 2\phi = 3^\circ\, 11'\, 6'',$$

$$CA = \frac{\overline{36}|^2}{6} = 6^3 = 216 \text{ in.} = 18 \text{ ft.};$$

$$\therefore\ Ae = 17\tfrac{1}{2} \text{ feet.}$$

We see then that, according to Lambert's formula, the instrument alone ought to be nearly six times as long as the distance to which it is desired to extend the hearing. In this case the speaker is supposed to stand at the distance of 36 inches from the external aperture of the trumpet. We see, by means of these formulæ, that in very deaf persons the trumpet must be made of inconvenient length in order to render the voice audible at the distance of 3 feet; but since the object of the trumpet is to convey as much sound to the ear by means of the instrument as the ear itself can collect at the lesser distance, it is obvious that if the orifice of one end of the instrument be one-third of an inch, and of the other end $1\frac{1}{2}$ inch (which are nearly the apertures of the human ear and mouth respectively), by applying the mouth to the larger end of the trumpet, nearly all the phonic waves will be reflected inwards and conveyed to the ear of the listener.

We can now easily account for the fact, that hearing-trumpets of very dissimilar characters answer tolerably, although if the principles on which some

are constructed be correct, those of others which seem to act equally well must necessarily be faulty; the reason is, that by putting the mouth close to or within the larger end of the trumpet, most of the voice is confined within its parietes and conveyed to the ear.

Having shown how, and on what principles, ear-trumpets should be constructed, I shall now very briefly enter upon the theory of speaking-trumpets. On this subject we are also indebted to the researches of Lambert for perhaps the only profound examination of the subject. His treatise is indeed chiefly devoted to speaking-trumpets, and he seems to have solved the problem of the proper form of such instruments, which had baffled Morland, Conyers, Hasse and others, who were his predecessors in the same inquiry. The object to be obtained by means of a speaking-trumpet evidently is to keep together and direct towards a distant hearer as many of the "phonic undulations," or, in other words, as much of the speaker's voice, as possible. This appears from the history of the instrument; since it was originally designed for the purpose of reinforcing the human voice, in order that the crews of ships passing each other at considerable distances might be enabled to communicate.

It is sometimes used by persons in the open air for attracting the attention of a multitude, and its use has also been suggested for military purposes; but the trumpet or bugle-horn is generally employed to make known to the soldiers the orders of commanding officers.

Sir Samuel Morland, who appears to have been one of the first to construct a speaking-trumpet, states that with an instrument which he made he was enabled to convey the voice to great distances; the dimensions were, length 5 feet 6 inches, diameter at the mouth 2 inches, and at the external orifice 21 inches.

In the construction of the speaking-trumpet there are several circumstances worthy of remark;—in the first place, the power of these instruments to produce a reinforcement of articulate sounds.

Now, that the intensity of the voice is capable of being greatly augmented by means of the speaking-trumpet is an incontrovertible fact; and, although the phenomenon appears at first sight to present (as Lambert observes) an acoustic paradox, for it seems as if the effect were greater than the cause, still, with the aid of the investigations of Lambert, Hassenfratz and others, it seems possible to give a philosophical solution of the problem.

We know by acoustics that the sound issuing from the mouth spreads in all directions and forms a sphere of undulations to a certain distance, depending on its initial intensity; it follows, that if the mouth be applied to the aperture of a conoidal speaking-trumpet, the sound, instead of expanding into a sphere, will be transmitted through the instrument; and we may therefore reduce the subject, as Lambert has remarked, to the considerations of certain geometrical relations of the sphere and cone.

When sound spreads unimpeded, it diminishes as

the square of the distance from its origin; so that, for example, two persons in conversation at 3 feet from each other will hear only one-ninth the quantity of sound that would affect their ears, were they at a distance of 1 foot; but the case is very different if the sound is made to traverse a cylindrical, or conoidal pipe. In the cylinder, when the internal surface is smooth and rigid, Biot has shown that very little sound is lost, except at very considerable distances, that is, provided the ear is placed at one end of the cylinder. But Lambert has proved that the cylinder is not well adapted for a speaking-trumpet, because the sound, after it has passed through the tube, is dispersed much more rapidly than after it has passed through a conoid.

The trumpet constructed for musical purposes derives its powerful tones from the vibratory movements of the column of air within its parietes, together with the reinforcement which is derived from the sides of the instrument entering into a state of oscillation synchronously with the vibration of the column of air.

The musical trumpet is of a conoidal figure, having its larger end expanded into a bell-shaped form, which has an influence on the quality of its tone, and assists in the distribution of the sounds. But those very qualities, which confer on this instrument its specific character and value, are circumstances which would be highly detrimental in a speaking-trumpet; since if the walls in the latter were thin and of elastic materials, the vibrations of the tube would materially

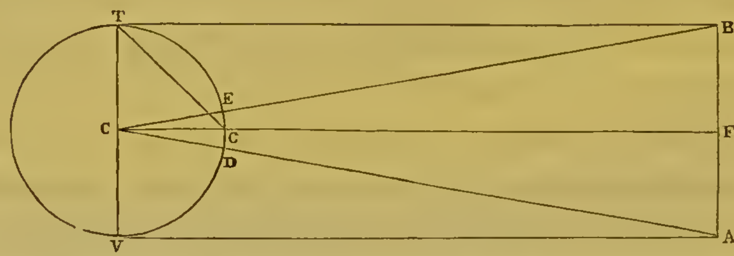
interfere with the distinctness of the articulation; for it is absolutely necessary when using the tube to speak very slowly; and, since the consonants are of short duration compared with the vowels, the former would be lost to the ear, and the vowel sounds only would be heard, rendering it very difficult to understand what was spoken.

We see, from these considerations, that the materials of a speaking-trumpet should be of sufficient substance to prevent the vibratory movement of the walls of the instrument from interfering with distinctness of articulation. Care should also be taken that the pitch of the voice be different from that of the trumpet; for when the voice and trumpet are of the same pitch, a resonance is produced, which also materially injures the distinctness of the articulate sounds.

But to return to the consideration of the cause of the reinforcement of the voice by the use of the speaking-trumpet.

If the walls of the instrument be sufficiently thick, so as not to interfere with the distinctness of articulation, the whole of the reinforcement of the voice may be attributed to the confinement of the air within the parietes of the tube, and to the reflexions of its undulations from the internal surface. Lambert has shown that precisely the same form of instrument is best adapted to the speaking- as well as to the hearing-trumpet, the only difference being in the size; for he takes the diameter of the opening of the mouth as $1\frac{1}{2}$ inch, whilst that of the ear is but $\frac{1}{3}$rd of an inch;

and since the former is four and a half times the latter, of course all the linear dimensions of the speaking-will be four and a half times larger than those of the hearing-trumpet.



The following is the result of the solution of the problem of speaking-trumpets by Lambert :—

Let BEDA be a tube in the form of a frustum of a cone, of which C is the apex, AB the base, and CF the axis ; ED, the embouchure, being a constant quantity, viz. $1\frac{1}{2}$ inch in diameter. With centre C and radius CE=BF describe the circle TGV, of which TCV is a diameter at right angles to the axis of the cone ; join TG, EG, TB, AV, the two latter will be tangents to the circle.

If now we conceive the quadrant TEG to revolve round the axis of the cone, it will generate a hemisphere, and the reinforcement of the voice by the trumpet will be to the voice without it as the surface of the hemisphere to the spherical segment generated by EG, that is, as $GT^2 : GE^2$.

From this it is obvious that the power of the instrument depends principally upon the angle of the cone, the power increasing as the angle diminishes ; but as the length of the tube increases likewise, there

is practically a limit to the power of the instrument for all useful purposes.

For the dimensions of speaking-trumpets Lambert gives an algebraical formula derived from the trigonometrical expression for the length of the side of the cone, founded on the variable range of the human voice; and we deduce from it an easy rule for the construction of the instrument of any given power. Let a be the range of a person's voice under ordinary circumstances, and b the range which he wishes to acquire by aid of the instrument; then if x be the length of the side of the cone,

$$x=\frac{3b^2}{8a^2}=\mathrm{CB};$$

whence this proportion,

$$\mathrm{CB} : \mathrm{CE} :: \mathrm{BF}\ (\mathrm{CE}) : \tfrac{1}{2} \text{ chord ED } (=\tfrac{3}{4} \text{ inch});$$

this gives the length CE, and therefore CB − CE, or the length of the side of the tube.

For example, suppose $a=\frac{1}{4}$ mile, $b=2$ miles,

then $$x=\frac{12}{\frac{1}{2}}=24 \text{ inches},$$

and $$\mathrm{CE}=\sqrt{18}=4{\cdot}24 \text{ inches};$$

$$\therefore \mathrm{BE}=24-4{\cdot}24=19{\cdot}76, \text{ about } 19\tfrac{3}{4} \text{ inches}.$$

Hassenfratz has disputed the accuracy of Lambert's theory, and says that in the speaking-trumpet Lambert has attributed the augmentation of sound to its reflexion from the wall of the instrument, whilst in other instruments it is caused by the vibration of the air contained in the tube; and he asks, "Why these two causes while the effects are analogous?"

The general conclusion which he draws from his own experiments are, " that the different sounds produced in the two cases are owing to the vibration of the air in the tubes, and their strengths or intensities to the augmentation of the amplitude of their vibration arising from the greater impulse which the air necessarily receives when it is enclosed in a tube." It appears from this statement, that Hassenfratz has not studied Lambert's work with sufficient attention; for the latter expressly mentions the augmentation of sound as being the result both of the vibration of the wall of the tube and of the reflexion of the air within it; and he then goes on to show that the first of these two causes would interfere with the distinctness of articulate sounds, and is therefore to be avoided, first, by the selection of inelastic materials; and secondly, by taking care not to speak in the pitch of the tube, in order that the resonance of the air in the tube may be prevented.

Now it seems that there is only one principle, properly so called, to which the two different results, namely the musical sound and the articulate, are to be referred, and that principle is the vibration of the air; but, in the first case, the object being simply to produce a musical effect, the direction of the reflected phonic waves is not considered in the construction of the instrument, as they have no effect on the pitch of the sound, but on the quality alone; whilst in the second case, the articulate sounds are not to be produced of the same pitch as that of the trumpet, and

the direction of the reflected rays is the only thing to be taken into the account in the instrument, which is formed entirely with a view of securing the concentration of the greatest number of waves along and around its axis. Hassenfratz* also seems to have drawn an erroneous conclusion when he attributes the intensity of sound to an increase in the amplitude of vibrations arising from some greater impulse which air enclosed in a tube necessarily receives. The passage is very vague, but it is clear that air set in motion by a given force must vibrate with the same velocity, whether it expands in open space or is confined within a tube; and the use of an instrument cannot possibly create any new force, but simply concentrates what already exists to the greatest possible advantage.

In concluding this brief outline of the theory of Hearing- and Speaking-trumpets, the author has been induced to lay it before the profession, in order that its members may have in our own language access to some rules for their guidance in the selection of these acoustic instruments†.

It has been no part of the author's plan to enter into any of the considerations relating to the diseases of the organs of hearing; he may, however, observe,

* Annales de Chemie, Prairial, An. xii.; and Nicholson's Journal, vol. xix. p. 233, A.D. 1804.

† Perhaps it may be useful to those who feel an interest in this subject, to notice that instruments according to the formulæ contained in this paper are constructed by Mr. Weedon, Surgical Instrument Maker, Hart Street, Bloomsbury.

that in those in which the membrana tympani is absent, Mr. Toynbee has proposed the use of an artificial membrane which he has invented, and of which he remarks,—

"The artificial Membrana Tympani has now been successfully used in every variety of case where partial or complete loss of the natural membrane has occurred, and I feel confident that in every case of deafness dependent upon such partial or complete loss of the natural organ, the artificial membrane will be found effectual in restoring the hearing."

This statement, coming as it does from a person of such extensive experience and reliable authority as Mr. Toynbee, needs no further remark from the author of this brief memoir.

THE END.

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ON ARTICULATE SOUNDS.

When it is considered that animals, especially those of the higher orders, are provided with a complex mechanism for the production and modification of sounds, that they are endowed with an exquisitely organized acoustic apparatus for transmitting the impression of sounds to the brain, and, lastly, that in the latter organ the nature and character of those sounds are perceived, and subjected to intellectual processes, it is reasonable to conclude that creatures so gifted were intended to employ those sounds for some beneficial purpose.

The modification of the voice depends on the development of the intellect; and, accordingly, the lower we descend in the scale of animal life, the less is the power of diversifying vocal sounds. Most of the orders of mammalia are provided with mechanism capable of producing an extensive range of sounds; but the intellect even of the highest quadrumana is not sufficiently developed, to admit of their applying these sounds for the purposes of articulate speech.

It is in the human race that we find the most varied and perfect adaptation of vocal sounds to the communication of ideas, both of material and intellectual subjects.

The sounds which in all ages have been selected by the different races of men to represent the ideas of things are, for the most part, purely conventional, and arbitrary, having in general no resemblance to the things themselves; since it is impossible by mere sound to imitate anything but sound, and therefore equally impossible to represent by the voice any other idea than that of sound itself, unless by common consent it shall have been determined that certain sounds shall serve to convey the notions of certain things. Hence, we need not be surprised that mankind, scattered over the face of the earth in different communities holding little or no intercourse with each other, would employ different sounds to express the same thing; at least where the thing intended to be designated had become known to a particular community after its intercourse with other nations had ceased.

The number of significant sounds or words must have increased with that of ideas and things required to be expressed in each society, according to its state of civilization; but, as sounds are transitory, and, so to speak, die at their birth, and as the modifications of them are constantly liable to change owing to their independent and arbitrary nature, it was found necessary to invent some

means of fixing them by visible representation, so as to render their influence permanent, and the sounds themselves capable of being recalled at pleasure; hence sprung the art of alphabetic writing.

The mechanism provided for the production of speech comprehends a large assemblage of organs. The most simple vocal sounds require the combined action of the lungs, windpipe, larynx, and respiratory muscles; and for articulate language an additional set of organs must be called into play, namely, the pharynx, hard and soft palate, uvula, tongue, teeth, lips, and nostrils.

All languages contain a certain number of elementary sounds, which are for the most part represented in their several alphabets; and it is of these sounds and their various combinations that all languages consist. But, although the whole of the elementary sounds which enter into all the known languages are comparatively few, they are capable of being combined into an immense variety of words; far greater, indeed, than is contained in all the languages of the earth taken together. The etymological investigation of languages belongs, however, to the philologist, while the structure and functions of the organs which produce their component sounds are the province of the anatomist, and physiologist.

After a lengthened inquiry into the elementary sounds of the various spoken languages which were

known in his time, Bishop Wilkins concluded that thirty-four letters, namely, eight vowels, and twenty-six consonants, are sufficient to express the whole of them.

Volney endeavoured to form an alphabet which should contain symbols for every articulation that occurs in every known language; so that each language might be read by any person with as much facility and precision in this new character, as by the native in its original character. For this purpose, he thought that about fifty-eight or sixty letters would be sufficient.*

Sir John Herschel,† however, considers that thirty-four letters, thirteen of which are vowels, and twenty-one consonants, are essentially necessary for the expression of the English language alone; and it is his opinion that, with two or three more vowels, and as many more consonants, or about forty letters altogether, representing precise and definite sounds, every known language might be reduced to a written form, in exact correspondence with its pronunciation. This, he thinks, would lay the foundation of a universal language, "one of the great desiderata at which mankind ought to aim, by common consent."

Among the examples which he gives of these thirteen vowels, several, however, admit of considerable doubt. For instance:—

* L'Alfabet Européenne appliquée aux Langues Asiatiques.

† Encyclopædia Metropolitana, vol. iv. Art. 'Sound.'

The vowel sounds in the words *hard*, *laugh*, &c., as likewise those in *lamb*, *hang*, &c., although represented by Sir John Herschel as different, appear to be, in each case, the same. Again, the A in *hare* is a diphthong. Now, if this be admitted, we may reduce the number of vowels in the table of Sir John Herschel from thirteen to ten, as stated below. Those who have not studied the subject can have little idea of the nice distinctions by which the vowel powers are separated; indeed, it requires an ear well practised in articulate sounds to be able to detect their acoustic differences with any degree of precision.

Marsden has constructed an alphabet consisting of thirty-five Roman characters, which he thinks contains a sufficient number of elementary sounds, to express by their combinations the oriental languages. "This," he observes, "may be appropriately termed a conventional alphabet, and is meant to be restricted to the especial purpose of expressing oriental, or other foreign words, literal or oral, and not to interfere with the established orthography of any country."* He however adds, that "the hope of seeing the accomplishment of such a literary coalition, or any material advance towards it, cannot be sanguinely entertained."

It is stated by certain writers that, among the Teutonic languages, the English has departed most

* On a Conventional Roman Alphabet, applicable to Oriental Languages. W. Marsden, London, 1834.

widely from phonetic principles; and that out of seventy thousand words, not more than seventy, or one in a thousand, are spelt as they are pronounced.

In order to correct our written language, and to spell words in letters which would express every sound as articulated in speech, it is proposed by the advocates of the phonetic system recently introduced, to revise and extend our alphabet, by making it consist of forty letters.

Lindley Murray has pointed out the importance "to every learner of the English language, of being able to pronounce perfectly and with facility, every original simple sound of which it is composed;" but he does not tell us *how* this is to be done, by what actions of the vocal organs these sounds are produced, or on what acoustic principles they depend. He alludes, it is true, to the long exploded views of Dodart for an explanation of the variations of tone, but he very properly leaves the subject of the physiology of articulation as a question beyond the pale of orthoëpy.

It is with the view of supplying this link in the chain of our knowledge of the vocal functions, that the following analysis of the physiology of the elementary sounds of our language has been undertaken.

In prosecuting this design, the theory of the vowel sounds will first be examined; premising, however, an explanation of some of the acoustic terms here

employed, such as vocalized, unvocalized, vowel, consonant, semi-vowel, mute, semi-mute, aspirate, sibilant, nasal, sharp, flat, &c.

VOCALIZED SOUNDS are those in which the vocal cords are in a state of vibration.

UNVOCALIZED SOUNDS are those in which the vocal cords do not vibrate.

VOWELS are sounds generated in the glottis, which pass freely through the mouth, and receive their peculiar distinctive characters in their passage. They form syllables without the aid of a consonant, and may be prolonged indefinitely.

CONSONANTS are sounds which are produced by the partial or total interruption of the vocalized or unvocalized breath by some of the organs of speech; and are therefore called "*Literæ clausæ.*"

SEMI-VOWELS are consonants capable of prolongation without the assistance of a vowel.

MUTES are unvocalized consonants, which must be associated with vowels to render them sensible to the ear; and are incapable of prolongation.

SEMI-MUTES resemble mutes; but are vocal, and capable of slight prolongation.

ASPIRATES are unvocalized sounds, caused by the breath rushing through the pharynx, or between the tongue and teeth, or lips and teeth.

SIBILANTS are hissing sounds, caused by the voice or breath passing between the teeth.

NASALS are vocalized sounds passing through the nostrils.

EXPLOSIVES are sounds produced by eondensed air in the vocal tube, when arrested in its passage from the lungs either by the velum, tongue, or lips; on the opening of which valves the air escapes in a gust. Explosives cannot therefore be prolonged.

SHARPS, called by some hard, are unvocalized consonants, sueh as P, T, F, K, S, &c.

FLATS, called by some soft, are voealized consonants, as B, V, Z, &e.

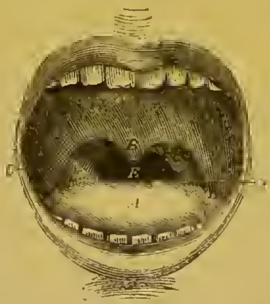


FIG. 1.—A view presented by the organs of articulation on looking into the mouth: A the tongue, B the uvula, C the velum, D the left tonsil, E the pharynx.

VOWELS.

When vowel eharacters are said by grammarians to possess various powers, it is merely meant that the same written letter may be sounded in as many different ways as there are powers assigned to it. These modifications are of two kinds; the one in

which, the articulation being the same, the difference lies in the time during which it is sustained, which constitutes the vowel either long or short;—the other depends on an alteration of the position of the articulating organs, whereby perfectly different sounds are produced, which ought to be represented by as many different symbols.

Vowels have been divided into three classes, having reference to the organs employed in their production, namely, guttural, palatal, and labial.

Guttural Vowels are produced by freely opening the mouth, while the fauces, and lining membrane of the pharynx, and velum pendulum palati, vibrate simultaneously with the glottis. The vowel sounds pronounced in *ball*, *bar*, *bat*, *but*, are guttural, and are produced without the interposition of the tongue, teeth, or lips; since the tongue may be moved into various positions during their utterance without altering their character.

Palatal Vowels.—In the pronunciation of these vowels, the sides of the tongue touch the molar teeth, and the dorsum is concave in the centre; whereby a channel is formed between the tongue and the palate, through which the voice is transmitted. The peculiar quality of these vowels is due to the vibrations of the membranes of the dorsum of the tongue, and palate. The vowels in *bate*, *bet*, *beat*, *bit*, belong to this class.

Labial Vowels are produced by a partial closing of the lips, accompanied with depression of the

tongue, and contraction of the cheeks, while the lips and cheeks vibrate simultaneously with the glottis. In order to produce the sound of o in *bone*, the lips are neither so much closed, nor so much protruded forwards, as in pronouncing that of oo in *boot;* the transition from the former to the latter of these sounds being entirely due to the change in the state of the lips.

In the English language there are ten distinct vowel sounds, imperfectly represented by five letters. They may be classified according to the manner in which they are anatomically and physiologically allied; as will be seen in the following diagram.

PHARYNGEAL.		LINGUA-PALATAL.		LABIAL.
ball	......	bate	......	
bar	......	bet	......	bone
bat	......	beet	......	boot
but	......	bit	......	

It must not, however, be supposed that these ten vowels are the only ones which exist, for the organs of speech are capable of producing several others which are found in foreign languages, as, for instance, the sound of *u* in the French *tu;* but the latter are unknown to English pronunciation, and we have confined ourselves to those which admit of being illustrated by words in our own language.

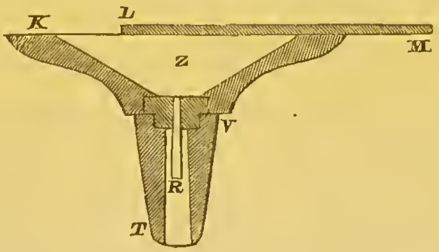
On the production of Vowel Sounds by artificial mechanism.—In a memoir presented to the Royal Academy of St. Petersburg, in the year

1779, Kratzenstein proved the practicability of producing the five ordinary vowel sounds by artificial mechanism, which he constructed and described.* He also calculated the relative degrees of aperture necessary for the production of each vowel.

About the same time, De Kempelen† succeeded in producing the vowel sounds by means of a reeded funnel-shaped apparatus, three inches deep from the mouth, and two inches in diameter. By inserting the hand, and moving it so as to vary the size of the aperture, he was able to modify the sound of the reed, so as to yield the qualities of the several vowel sounds.

Mr. Willis,‡ having succeeded in producing the vowel sounds on De Kempelen's plan, was induced to try other means of accomplishing the

Fig. 2.



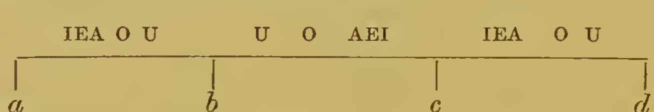
same effect. Having fitted a free reed, R, to the bottom of a funnel-shaped cavity half an inch deep,

* Journal de Physique, vol. xxi.

† 'Le méchanisme de la parole, suivi de la déscription d'une machine parlante.' Vienne, 1791.

‡ Cambridge Philosophical Transactions, vol. iii.

and two inches in diameter at the top, of which Z (fig. 2) is a section, the pipe T V standing on a wind-chest, he found that by sliding a flat board, L M, across the top of this funnel, which is only one-sixth the depth of De Kempelen's, the hand was unnecessary; for by merely enlarging the opening, K L, he produced the whole series of vowels in the order U O A E I.* He also found that cubical, and other shaped cavities answered the purpose equally well with those used by his predecessors. The success of these attempts induced him to try the effect of cylindrical tubes, and for this purpose he constructed an apparatus consisting of tubes sliding on each other, the successive portions of which were multiple lengths of the first tube, and capable of being drawn out at pleasure over a fixed piston furnished with a reed. He used a free reed similar to that of Kratzenstein, which is considered to yield a sound most nearly resembling the tones of the human voice.



Suppose the reed, and closed end of the tube to be at the point *a*, and let *ab*, *bc*, *cd*, be each equal to a stopped pipe in unison with the reed. If the tube be now drawn out gradually to I, E, A, O, U, the

* It must be borne in mind that the sounds here assigned to the vowel letters, are those which are given to them in the Continental languages.

pitch of the reed remaining the same, its tone will assume a succession of vowel qualities, corresponding to these letters in the diagram. As the elongation proceeds from *b* to *c*, the same vowels are repeated, but in an inverted order, and so on in cycles, each being a repetition of the primitive series, but the vowels becoming less distinct in each successive cycle; the distance of any given vowel from the centres *a*, and *c*, being the same in all the cycles. If another reed, having a different sonorous wave, be adapted to the same pipe, the same phænomena will be produced, the central points of the new cycles being now at distances from each other which are equal to the length of the new sonorous wave, but the distances of the several vowel points from the centres of the respective cycles will be the same as before; so that, generally, if the reed wave $a\,c = 2\,a$, and the length necessary to produce any given vowel from the point a, be equal to v, the same vowel will be constantly produced by a pipe whose length is $= 2\,n\,a \pm v$, n being any whole number.

When the pitch of the reed is so high, that the length of its wave is less than twice the distance corresponding to any vowel, the production of that vowel, and of all beyond it, will become impossible. Thus, if we suppose $a\,c$ to be less than $2\,a$ U, but greater than $2\,a$ O, the series of sounds will never extend to the vowel U; but, on lengthening the pipe indefinitely, the succession of vowels will be I E A O,

O A E I. If the pitch of the reed be still higher, more vowels will be cut off. This Mr. Willis considers to be exactly the case in the human voice; and he observes that female singers cannot pronounce the U and O on the higher notes of their voices, that is, higher than the double octave above the middle C of the piano, or a stopped pipe whose length is = 4·7 inches, and which yields the vowel O.

Mr. Willis found, on measuring the length of the pipe from *a*, that the pitch corresponding to each vowel was as follows.

VOWEL.	POWER.	LENGTH OF PIPE IN INCHES.	PITCH.
I	See	0 .38	g^{v}
E	Pet	0 . 6	c^{v}
	Pay	1 .	d^{iv}
A	Paa	1 . 8	f'''
	Part	2 . 2	$d''\flat$
A°	Paw	3 . 05	g''
	Nought	3 . 8	$e''\flat$
O	No	4 . 7	c''
U	But		
	Boot	Indefinite.	

On inspecting the foregoing table, we see that the length of pipe required in order to produce the vowel quality A°, is ten times as great as the length for the vowel I; and that, while the reed sounded C, which beats 512 times in a second, the pipe yielded g'' for the vowel A°; so that, as Mr. Willis remarks, their combined effect is g'', g'', g'', 512 times in such rapid equidistant succession as to produce c', g'' si-

multaneously. If another reed were applied to the same pipe, vibrating 340 times in a second, the pitch of the reed would be *f*, but the vowel would still be A°.

After a careful examination of the nature of the effects of the joint system of reed and pipe, such as has been described, on the column of air, Mr. Willis considers that the vibrating tongue of the reed generates a series of pulsations of equal force at equal intervals of time, which are alternately condensed, and rarefied. These, which he calls the primary pulsations, are followed by a series of secondary pulsations of decreasing strength, at equal intervals of time from their respective primaries, depending on the length of the attached pipe. From the co-existence of these primary and secondary pulsations, "there results a series, consisting of the repetition of one musical note in such rapid succession as to produce another," the secondary pulsations adding the vowel quality to the primary note of the reed.

Mr. Willis concludes "that, whatever effect be produced on the ear by applying a pipe (of a length $= s$,) to a vibrating reed whose note is in unison with a stopped pipe, (of a length $= a$,) the same will be produced by a pipe $2na \pm s$." He also remarks that the pitch of the sound produced is always that of the reed, but that the vowel produced is always identical for the same value of s. Hence it would appear that the ear, in losing the

consciousness of the pitch of *s*, is yet able to identify it by this vowel quality.

The fact of the same results having been attained by apparatus differing in form, proves that the production of the vowel sounds does not depend on the shape of the aperture through which the air passes. Professor Faber very recently exhibited a piece of mechanism designated "Euphonia, or Speaking Automaton." It was composed of a bellows, a caoutchouc larynx, and some hidden movements which were acted on with the fingers by means of sixteen keys, like those of a pianoforte; and it had a second set of keys by which the pitch was regulated. This instrument had engaged the attention of M. Faber upwards of twenty-five years, and was able to produce immediately any words called for, to articulate entire sentences, to whisper, and to sing the national anthem, "God save the Queen." The particular mode by which the various elementary sounds were effected was not divulged.

Sir John Herschel inquires, "What is it that constitutes the essential character or distinction between vowel and vowel, and on what part of the mechanism of the voice do the vowel sounds depend?" Kratzenstein and De Kempelen considered that the condition necessary, for changing one and the same sound into different vowel qualities, depended upon the size of the oral opening, and the oral canal, the latter being, according to De Kempelen, the space between the tongue and palate. By dividing

the spaces of these apertures into five parts, De Kempelen estimated the dimensions for the production of the five English vowels as follows:

VOWEL.		SIZE OF ORAL APERTURE.	SIZE OF ORAL CANAL.
a	as in far	5	3
e	as (*a*) in name	4	2
i	as (*e*) in theme	3	1
o	as in note	2	4
u	as (*oo*) in cool	1	5

These estimates show the relative position of the organs of speech, but do not on any acoustic principle explain the influence which these changes exert, in passing from one vowel to another.

If the qualities of sound by which the vowels are distinguished depended *simply* on a certain number of vibrations, like that which determines any given note in music, it would be very easy to designate the vowels by the pitch. But, in the case of the vocal organs, all the vowels may be conveyed in a whisper, and they may all be produced in succession on a single musical note. If, again, they depended only on the configurations of the vocal organs, no mechanism incapable of similar configurations could produce them artificially; but, this having been accomplished by Kratzenstein, De Kempelen, and Willis, by means of instruments which differ much in their construction from the vocal organs, it is evident that the difference of sound of the several vowels does not depend on configuration alone; a conclusion which is further confirmed by the

power of articulation possessed by many birds, whose vocal organization is very different from that of the mammalia.

According to Euler, "the pitch of sounds depends on the number of vibrations in a given time; loudness, on the greater or less extent of the excursion of the particles; quality, and the vowel sounds," he thinks, "must depend on the form of the curve by which the law of density and velocity in the pulse is defined, or upon the latitude of the pulse;" but this, Mr. Willis observes, he offers as "a mere opinion, unsupported by experiment, save that to account for the peculiar quality of sound by which we know a flute from a trumpet, &c.: he remarks that, as the vibrations of each instrument are excited in a manner peculiar to itself, its pulsations must also follow peculiar laws of condensation and motion, by which he thinks the sound will be characterized." *

In the application of the theory of vowel sounds to the mechanism of human voice and speech, there are two hypotheses which would equally satisfy the conditions for their production artificially. The first is, that the glottis produces the primary, and the *air* in the pharynx, mouth, and nostrils, the secondary or vowel quality pulsations. The second is, that the glottis produces the primary, and the *membranes* of the pharynx, mouth, and nostrils, produce the secondary pulsations of the air. Dr. Thomas

* Cambridge Philosophical Transactions, p. 234.

Young* seems to have entertained an opinion favourable to the first hypothesis. He observes, "The reflection of the sound from the various parts of the cavity of the mouth and nostrils, *mixing* at various intervals with the portions of vibrations directly proceeding from the larynx, must, according to *the temporary form of the parts*, variously affect the laws of the motion of the air in each vibration; or, according to Euler's expression, the equation of the curve conceived to correspond with this motion; and thus produce the various characters of the vowels, and semi-vowels." He further remarks, that "the nose, except in nasal letters, affords but little resonance; for the nasal passage may be closed by applying the fingers to the soft palate, without much altering the sound of vowels not nasal."

In taking the second view, it must be borne in mind that membranes exert a great influence on vibrating reeds. The researches of M. Savart on this subject are familiar to every one who has studied the acoustics of membranes; and we know by experience that the breath passing through the glottis is thrown into a certain state of vibration, and reaches the cavity of the mouth, which is already so disposed as to present a proper extent of its own membranes to the action of the breath. By these means the membranes are also made to vibrate, and these latter vibrations, co-existing with the original vibrations of

* Natural Philosophy, vol. ii. p. 550.

the glottis, may generate the vowel sounds. A peculiar configuration of the mouth and pharynx is at the same time necessary for each vowel; and this is the true criterion by which we are to decide whether two vowel sounds are essentially different, for, whenever we pass from one simple vowel to another, the configuration is necessarily changed.

If, indeed, we attentively examine what takes place whilst the organs change from one vowel sound to another, we can easily detect different parts of the membranous lining of the pharynx, tongue, lips, and other soft textures of the mouth forced into vibratory motion, attended with a variety of configurations, and these different motions and configurations may, by disposing different membranous surfaces to a state of vibration co-existing with the glottis, determine the quality peculiar to the several vowel sounds.

From the researches already mentioned it would appear, that the vowels may be produced in several mechanical ways, and that the mechanism used need not be a fac-simile of the organs of speech, since the peculiar figure of these is not a necessary condition for the imitation of the sounds in question. The vowels, then, may be considered as sounds which are distinguishable from each other by definite peculiarities, and which, at least in the human organs of speech, are accompanied with certain definite actions and configurations, which are essential to them in consequence of their general construction.

This is obvious from the fact that children, when learning to speak, do not copy the actions of the vocal organs by visual inspection, but, when imitating the sounds which they hear, unavoidably produce the same configurations.* If, on the other hand, the configurations were not due to the peculiarity of the structure and mechanism, a thousand persons might utter the same words, while their vocal organs were in as many different positions. This, however, we know is not the case; for, so regular and definite are the actions of the organs of speech, that there are persons who, having entirely lost the sense of hearing, can yet understand what is said to them, by attentively observing the variations of the mouth during conversation.

DIPHTHONGS.

The vowels are in general capable of being combined two and two, and there results a series of secondary sounds, or diphthongs; but, unless the simple vowels are sounded rapidly in succession, the secondary sound will not be heard, and no diphthong will be produced. Diphthongs, however, are not merely sounds resulting from the combination of two simple vowels, *ou*, *ew*, *oi*, following each other in rapid succession, but are also in part the effect of the movements of the articulating organs on the vowel sounds, during the transition of these

* Hence those born perfectly deaf cannot imitate articulate language.

organs from the position of the first vowel to that of the second.

Some vowels do not easily combine, and when written in conjunction are not pronounced as diphthongs: others, again, are capable of being combined in triads, or triphthongs. Certain grammarians have asserted, that no one syllable consists of three vowels, and that there are consequently no triphthongs; but this is evidently a mistake, as *wound*, *why*, *your*, &c., are compounded of three vowel sounds which easily coalesce with each other.

CONSONANTS.

In the production of consonants, the whole mechanism of voice and speech is called into action in a variety of ways, so as to modify the sounds in a distinct and perceptible manner. Much confusion has arisen respecting them, owing in some measure to the arbitrary substitution of the sound of one letter for another, and the want of determining the exact and precise power and place of each character.

If we examine the consonants in groups, according to their natural, or physiological affinities, that is, as they are articulated by corresponding organs of speech, the labials, namely, B, P, V, F, M, will first claim attention.

B is a labial semi-mute, produced in the following manner. The lips being closed, the breath held in a state of condensation, and the glottis in the

vibrating position, the lips are then suddenly opened, and the sound assigned to the letter B, together with the vowel by which it is followed, is heard; as in the words *bat*, *tub*, &c.

P is a perfect mute, produced in a manner very similar to that of B; but the lips are more firmly pressed together, and the explosive force of the breath is stronger. If the hand be placed before the mouth, whilst these two letters are alternately and rapidly pronounced, the difference in the explosive force and action of the breath can be very perceptibly distinguished; as in *pat*, *tap*, &c.

V is a labio-dental semi-vowel. If the mouth is kept in the same position as in pronouncing F, and the glottis is made to vibrate, the vocalized breath in passing between the lip and the teeth causes the surface of the lip to vibrate and produces the buzzing quality of v, as in *van*, *have*, &c.

F is a labio-dental aspirate. It is produced by the inner surface of the margin of the under lip being brought into contact with the outer edges of the incisor teeth of the upper jaw: the unvocalized breath is then forced out between the lip and the teeth; as in *fat*, *staff*, &c.

W.—This letter is said to partake, in the English tongue, of the nature of both vowel and consonant. But, if we consider it capable of being decomposed into UU, as its name imports, it must always be a vowel. It has been regarded as a consonant in the English words *water*, *wood*, &c.; but this is a mistake; since the diphthong sound at the commence-

ment of these words may be decomposed into *ua*, and *uoo*, where U has the power of the French *ou*, or the English *oo*. The letter W is not used either in the French or the Italian language, and is pronounced by the Germans like the English V; whence, probably, the above mistake has arisen.

NASALS.

M, N, NG.

M is a labio-nasal semi-vowel, and may be indefinitely prolonged. Here the glottis vocalizes the breath; the lips are closed, as in pronouncing B, but the sound passes through the nostrils. It is, therefore, the result of a labio-nasal action, and its peculiar character is owing to the surfaces of the closed chamber of the mouth, and the open apertures of the nose, entering into a state of vibration synchronous with that of the glottis. The nasal character of M renders it unfit for frequent use in musical composition.

N is a lingua-nasal semi-vowel, produced by the dorsum of the tongue resting against the palate, and closing the passage through the mouth, whilst the sounding column of air is propelled through the nose. The most simple sound of N is heard in the words *no*, *nut*, *tun*, &c. Its softest sound is heard in the words *miniature*, *minion*, *maniac;* and is the Spanish *ñ* in *señor*.

NG is a lingua-nasal semi-vowel. Here the dorsum of the tongue intercepts the sound at a short distance in front of the velum, and the breath passes

through the nose, which is in a state of sensible vibratory motion. This is a simple sound, and not the resultant of the letters N G combined, as is evident from the mode in which the sounds of these letters are produced; it should therefore have a distinct symbol to represent it.

LINGUA-DENTALS.

In the production of the next class of consonants T, D, TH, DH, the tongue is the organ most actively employed.

T is a perfect mute, produced by pressing the tip of the tongue against the roots of the incisor teeth of the upper jaw, the breath being condensed by the muscles of expiration, and the pharyngo-nasal apertures closed, while the glottis is maintained in the vocalizing position;* so that, the instant the tongue is withdrawn, the aspirate sound is heard in combination with the vowel, or consonant, by which it is followed.

D is a lingua-dental semi-mute: the position of the tongue is nearly the same as in pronouncing T, but the breath is less condensed, and the sound is vocal. T and D stand in the same physiological and acoustic relation to each other as P and B.

There are two sounds represented by TH and DH,

* For an account of what is termed the vocalizing position of the thyro-arytenoid ligaments, the reader may consult Mr. Willis's paper in the Cambridge Phil. Trans., vol. iv., and the author's paper on the 'Physiology of the Human Voice,' in Phil. Trans., 1846.

as if they were the resultants of T and D combined with H, the TH being aspirate, and DH vocalized: but these again are simple consonants, produced by protruding the tip of the tongue under the edges of the upper teeth, between which the air escapes as a whisper in the former case, but mixed with a certain amount of vocal sound in the latter. Our ancestors, the Anglo-Saxons, used distinct characters for these two consonants; namely, ð for *dh*, and þ for *th*; thus they wrote *Faðer*, *Moðer*, *Faiþ*, *þief*, *father*, *mother*, *faith*, *thief*. Dr. Latham* remarks, that the greatest mischief done by Norman influence to the English alphabet was the rejection from it of þ and ð. In other respects the alphabet was improved; the letters Z, K, J having been either imported, or currently recognised.

The pronunciation of these sounds is extremely difficult to foreigners; some of whom, even after a residence of many years in England, never succeed in acquiring it, owing to their pressing the tip of the tongue against the roots of the incisor teeth of the upper jaw, instead of protruding it beneath them.†

* The English Language, by R. G. Latham, M.D.

† The sound which accompanies the production of the semi-mutes B, D, G, is confined to the mouth, the opening from the nares into the pharynx being closed. We can easily detect the state of the nasal valve in these semi-mutes, by pronouncing words containing syllables ending in B, D, G, followed by others beginning with N; as *abno, agno, adno,* during which the opening of the nostrils, on sounding N, can be sensibly felt.

LINGUA-PALATALS.

L, R.

L is a lingua-palatal semi-vowel, produced by pressing the tip of the tongue against the palate, and leaving a chink on each side for the passage of the vocalized breath, by which its acoustic character is given.

R, termed *litera canina*, is produced by causing a vibratory movement of the tip of the tongue near to, and sometimes touching, the palate. Its character is more or less marked according to the force of the breath, and the extent and number of vibratory alternations effected by the tongue: sometimes one vibration only is made, and at others several, the tongue acting like a free reed.

The double L of the Welsh, and the double R of the Greeks, and of some other nations, are produced in the same manner, but, in each case, during one continuous emission of breath, the articulation begins with a whisper, and ends with a vocal sound.

LINGUA-DENTALS.

S, SH, Z, ZH.

The two former of these may be more properly called sibilant, and the two latter buzzing consonants.

S, (termed, from its hissing character, *litera serpentina*,) is produced by a strong current of the unvocalized breath passing through a chink formed between the upper and under incisor teeth, the

tongue lying a little above the level of the chink. In English, the proper power of S is heard in the words *sit*, *abyss*, &c.

Z.—When the breath is vocalized in passing between the teeth as in *s*, the sound of *z* is heard. It is sometimes called *s* soft, and is properly the sound of the Greek ζ.

ZH, and its corresponding aspirate *SH*, have no distinct symbols, though they are simple consonants, and not the resultants of the letters by which they are represented. The latter sound is heard in the words *shop*, *fish*, *rush;* and the former is that of the letter J, as pronounced in the French language in *je*, *joli*, &c.; also in the English words *measure*, *azure*, &c. In the production of ZH, and SH, the disposition of the teeth and tongue is very nearly the same as that for the sounds Z, and S; but the tip of the tongue is elevated rather higher than in the latter, or nearly to the level of the gums of the incisor teeth. The variation in the position of the tongue is sufficient to produce the acoustic differences by which these sounds are distinguished.

J is a lingua-dental, resulting from the combination of the letters D, and ZH; and is the same as the soft G before E and I, as in *ginger*, *gem*, &c., or the J in *June*, *January*, *joy*, &c. In the French language it loses the sound of D, and retains only that of ZH, as *Juin*, *Janvier*, *joie*, &c. The Italians and the

Germans give the letter the power of Y, as in *jeri*, yesterday; *jahr*, year; and the English pronounce it similarly in the word *Hallelujah*. The Dutch represent the sound by D*sj*.

CH soft, T*sch* German, T*sj* Dutch, the sound of which is heard in *charm*, *charter*, and not the guttural sound K or C hard, improperly represented in the words *character*, *chemist*. The articulating organs pass through the positions of T and SH, as above explained.

X has the sound of Z at the beginning of words, but in the middle, or at the end of words and syllables, it assumes the power of KS, or KZ. It is not used at the beginning of English words.

GUTTURALS.

C, CH, Q, G, GH.

The legitimate sound of C hard, as heard in the words *corn*, *caper*, &c., is identical with that of K; one of which letters is, therefore, superfluous. It is a guttural mute, produced by the breath intercepted between the dorsum of the tongue and the velum, while the air is condensed in the pharynx, whereby an explosive sound occurs on withdrawing the tongue, and opening the vocal passage.* The letter

* Sir Charles Bell observed in a person, the bones of the upper part of whose face were lost, so that one could look down behind the palate, and thus witness the operation of the velum palati, that "during speech it was in continual motion; and when this

C is improperly substituted for S in words where it is followed by E, I, and Y, as in *licence*, *docile*, *cynosure*.

In combination with H it sometimes takes the hard sound, as in *chemist*, *chronic*. It is then sounded as a simple consonant, equivalent to the power of the Greek κ.

K.—The preceding remarks will suffice for the letter K, as its sound is produced precisely in the same manner as that of C hard.

G has two sounds in the English language; the one termed hard is heard in the words *game*, *gravity*, *egg*, &c.; the other soft, in *genius*, *George*, *ginger*, &c. The former is a lingua-palatal semi-mute. It is produced by pressing the dorsum of the tongue against the soft palate. The breath is then condensed in the pharynx, whilst the glottis is held in the vocalizing position, in order that the breath may be put into a state of vibration the instant the pharynx is opened.*

G soft is composed of the action of D, and a soft

person pronounced the explosive letters, the velum rose convex, so as to interrupt the ascent of the breath in that direction; and as the lips parted, or the tongue separated from the teeth or palate, the velum recoiled forcibly."—Phil. Trans. 1832, p. 311.

* Sir Charles Bell was of opinion that the pharynx exerts considerable force in the production of the explosive consonants, and that by its aid persons are enabled to continue speaking much longer than they could otherwise do. He observes that "if we grasp the throat whilst speaking, so that the finger embraces the bag of the pharynx, we shall feel that every articulate sound is attended with an action of the pharynx; and preceding each explosive letter, we shall be sensible of a distention of the throat." —Phil. Trans. 1832, p. 311.

sibilant transmitted through the teeth, and is identical with the sound of J, as heard in the names *John*, *James*, &c. G hard bears the same physiological and acoustic relation to K, as D to T. Its substitution for J should not be used.

GH is a guttural, used in the Irish, Italian, and Persian languages. In the English words, *light*, *daughter*, *though*, the letters remain, but the sound of the *gh* has long been dropped.

Q.—The letter Q, which is always used in combination with U, is equivalent to KU.

H is a guttural aspirate, produced by forcing the unvocalized breath through the mouth, and combines easily with all the vowels as, *ha*, *he*, *hi*, &c.

The following tabular classifications of the consonants must be regarded as only approximatively correct, and have been here introduced in order to avoid complexity of detail.

ANATOMICAL AND PHYSIOLOGICAL CLASSIFICATION.

LABIAL.	LINGUA-DENTAL.	LINGUA-PALATAL.	LINGUA-PALATO-NASAL.	PHARYNGEAL.
B ...	SH ...	L ...	N ...	G
P ...	ZH ...	R ...	NG ...	K
LABIO-DENTAL.	TH ...	D	LABIO-NASAL.	H
V ...	DH ...	T	M	
F ...	S			
	Z			

ACOUSTIC CLASSIFICATION.

Mutes	P, T, K.	Sibilants	S, SH.
Semi-mutes . . .	B, D, G.	Aspirates	H, F, TH.
Nasal	M, N, NG.	Liquids	L, R.
Buzzed	V, Z, ZH.		

According to the preceding analysis, there are ten vowels, and twenty consonant sounds in the English language, the physiology of which has now been briefly explained. In our Alphabet, however, we find that several of the characters represent compound sounds, and that some elementary sounds have duplicate characters, whilst others have no special characters assigned them at all. Thus, in the first case, $x = ks$, $q = ku$, g and $j = dzh$, $ch = tsh$; in the second case, $c = k$, $f = ph$; and to the third case belong *dh*, *th*, *zh*, *sh*, *ng*.

In the English language, consonants are seldom, if ever, reduplicated in the same word; but, when two words are conjoined, whereof the first ends, and the second begins with the same consonant, such as book-case, &c., reduplication takes place; that is, the vocal organs which close on the first pronunciation of the consonant, re-open after a slight interval on the second.

In order to form a universal alphabet, and mode of writing languages, so that the natives of one country might read and sound the language of any other, it would be necessary, first, to have as many characters as would represent the elementary sounds of all languages, and then to assign to each character a single definite power of a standard acoustic value. In combining these into syllables, the sound of each syllable should always be the resultant of the component elementary sounds, and should not admit any arbitrary variations. It is probable that no

alphabet has the number of separate characters sufficient for this purpose; and that no language has hitherto been fully represented on the acoustic and phonographic principles here laid down.

The difficulty of interpreting hieroglyphics, which are perhaps only in part alphabetical, is well known. The Chinese characters are entirely ideagraphic, representing objects, and ideas,* and not sounds. The effect of this is that, although the inhabitants of one province may not understand the dialects of other provinces, they use the same characters for the same ideas, and things; and the author is informed by a gentleman who has resided many years in China, that he has often seen one Chinese, in conversation with another of a different province, describe the figure of the characters by a flourish of his parasol in the air, when their vocal language was so different as to be unintelligible to each other.

The Roman alphabet, which is now in such general use, is very defective in acoustic representation. In several European languages its orthoëpy is indefinite, arbitrary, and continually changing, and we find that we cannot without difficulty read our own language as it was written only a few centuries ago. The following is an example of the Lord's Prayer, as it was written by the English about the seventh century.†

Uren fader thic arth in heofnas, sic gehalgud

* See Penny Cyclopædia, vol. xii., Art. 'Hieroglyphics.'

† Camden's Remains, p. 23.

thin noma: to cymeth thin ric, sic thin willa sue is in heofnas and in eortho. Uren hlaf ofer wirtlic sel us to daeg; and forgef us scylda urna, sue we forgefen scyldgum urum; and no inlead usith in custnug. Ah gefrig urich from ifle. Amen.

Several of the subsequent changes which this prayer has undergone will be found in the Philosophical Transactions, 1668.

Bishop Wilkins has endeavoured to frame alphabetical characters in conformity with the configurations of the vocal organs in pronouncing them; and this is, perhaps, the nearest approach yet made towards a definite relation between the written letters, and the action of the organs in their production. He has constructed thirty-four of these characters, as fundamental to the formation of a "real character, and a philosophical language," the principles of which he has given in detail.

If the elementary sounds of letters were constant, and if the true resultant sounds of their various combinations into syllables were always preserved, there would be no difficulty in giving the proper sounds of words in any language, when once the alphabet had been perfectly acquired. In correcting the orthography of the English language on orthoëpic principles, great care should be taken—First, that letters representing the proper sounds be substituted for those now improperly used: Secondly, that in fixing the pronunciation, the most approved standards, such as the stage, the

pulpit, the bar, and the senate be consulted. It is chiefly through the neglect of these precautions, that the authors of the phonetic system have brought that project into ridicule. Their system of vowels is, moreover, imperfect; and their combinations of characters betray a pronunciation strongly savouring of that used by the uneducated classes of society.

In the employment of elementary sounds for the expression of ideas, whether conveyed in the form of melody, as in singing and recitative, in reading aloud, or in speaking, the principles of enunciation are the same; the distinction is only in the choice of the melody, which, however, is susceptible of great variety, and, in certain sentences, determines the meaning of the speaker. Pauses, accents, cadences, and choice of melody and time, aided by gesticulation in delivery, are all called into action by the finished orator, in order to render his subject impressive, and to secure the attention of his audience. Few, however, either in the pulpit, at the bar, or in the senate, attain by exercise that excellence in the method of expressing their ideas, of which the vocal organs are susceptible. In speaking, the proper intonation, time, accent, quality, and intensity, adapted to the magnitude of different assemblages, cannot indeed be acquired without much study and practice; and, as the art is little understood, and less cultivated in our schools, we need not be surprised that so few

persons are to be found in society capable of expressing their ideas in a manner satisfactory either to themselves, or their hearers. An exposition of the principles of intonation would be foreign to the object of this treatise; but every one must have observed as many shades of intonation as there are diversities of physiognomy; and hence we can recognise a friend by his voice, that is, by his peculiar *method* of intonation, and use of the articulating organs.

We have now concluded an anatomical and physiological explanation of the modes in which the several vowels and consonants of our language are produced; nor is this a merely speculative inquiry for the amusement of the curious, but a subject of high practical importance; for, unless the normal action of the vocal mechanism is thoroughly understood, it is impossible for the medical practitioner to undertake, with any probability of success, the cure of those distressing cases of defective pronunciation, and hesitation of speech, which are so frequently committed to his care.

IMPEDIMENTS OF SPEECH.

It is now well understood that the study of the physiology of voice and speech is surrounded with considerable difficulties. The acoustics peculiar to the vowel sounds have attracted the attention of the most distinguished mathematicians, and any attempt to analyze them involves very profound considerations. The investigation of the consonant sounds is not, however, involved in the same obscurity. The whole of the vocal mechanism during speech is under ordinary circumstances governed by the will.

But, since we find the parts of the mechanism so multifarious, and the conditions of their normal functions in voice and speech so numerous, we need not wonder that they should frequently present a great variety of irregular and disordered actions; indeed, the more the subject is investigated, the more must the investigator be impressed with the conviction that it is more wonderful that the majority of persons speak properly, than that a comparatively small number speak imperfectly. The difficulty of speaking our language is much increased,

especially to foreigners, in consequence of its exceedingly imperfect orthography; the same symbol being often made to represent several different elementary sounds in different combinations; so that, in certain words, it becomes a matter of uncertainty what should be the real sound of the symbol. To persons acquainted with the physiology of voice and speech, it must be obvious that the abnormal states may be various in their nature, and that, accordingly, their treatment must be equally various: any dogma of there being a single remedy must, therefore, necessarily be incorrect. They may originate in the mental processes, or in those states and conditions of the system which tend to disturb the mental associations, and power of volition. Other causes may exist in some peculiar states of the organs of hearing, or in irregular movements of the glottis, or of any of the articulating organs; indeed, it is not common to find any two cases precisely similar in reference to cause and effect.

The investigation of the causes of those defects in articulation which are usually comprised under the general terms *stammering*, and *stuttering*, has, until a very recent period, been much neglected by the medical profession; and the consequence has been, that this class of cases has fallen into the hands of uneducated empirics. Surgeons have, however, at length been aroused from this state of indifference by the energetic proceedings of Dieffenbach, Scott, Yearsley, and others. It has

been supposed by these authors that stammering is the result of some abnormal condition of one or more of the organs which compose the vocal apparatus, such as the frænum linguæ, the velum, uvula, tonsils, or some of the muscles of the tongue, &c. After proposing this hypothesis, the next rational step would have been to inquire whether such hypothesis strictly corresponded with the functions of the several parts in question, in reference to the production of voice and speech. Had this been previously done, we should never have heard of the many surgical mutilations of these organs, which have taken place both at home and abroad; since, even without the attainment of anything approaching to an accurate knowledge of the normal functions of these parts, it might easily have been ascertained by a little inductive reasoning, that some of the parts which have been subjected to operations could not possibly be concerned in the production of the malady.

Independently of voice and speech, the vocal organs are more or less concerned in the functions of respiration, deglutition, and the special senses of hearing, smell, and taste. Owing to the complex apparatus of the vocal organs, difficulties of the most formidable nature present themselves in the study of their physiology, and pathology, and it can therefore easily be understood how surgeons may often be mistaken respecting the causes and seat of these complaints. A

little attention to the action of the vocal apparatus during the act of stammering will, however, soon enable a competent observer to discover whether the affection is entirely of a functional character, or dependent on some organic lesion of the parts concerned in the production of articulate language. When it is of the former character, we may easily see the cause of the ill success which has often attended the operations which have been performed for the relief of this defect. It is true that, in infants, the frænum linguæ may be, and indeed often is so short, that they are unable to grasp the nipple of the mother, and consequently requires to be cut; but it is rarely so short as to prevent the tip of the tongue from touching the roof of the mouth; and if the letters *d*, *t*, *n* can be sounded, the point of the tongue has sufficient mobility for articulate speech. It may also be easily understood that, if stammering depended on malformation of some of the muscles of the tongue, as was supposed by Dieffenbach, the defect would be permanent, and consequently, that stammerers would not at one moment be able, and at the next unable, to articulate the same words, as is well known to be often the case.

It has been supposed by some that the tonsils are instrumental in the production of stammering. The tonsils may, it is true, affect both the pitch, and the quality of the voice, but these results are entirely independent of stammering. They may, indeed, be

so much enlarged as to impede deglutition, and block up the internal passages to the ears; or they may be ulcerated, and involve the surrounding tissues, but still without producing any sensible effects on the articulation. The velum is under the control of the voluntary muscles; and, if it should be found on investigation to be instrumental in the production of stammering, it may easily, by a method which will presently be described, be made to act so as to keep the vocal tube open. The uvula cannot close the vocal tube in speaking, and consequently cannot be concerned in producing the defect of speech under consideration.

It has been truly remarked by Sir Charles Bell that for the production of the most simple sound, or the articulation of a single word, the consent of a great number of organs is necessary. Dr. Arnott also observes, that command over the organs of speech is acquired in the same manner as over all the muscular organs of the body; as, for example, in walking, skating, fencing, and performing on musical instruments. Agreeably to this view, it will be found on analysis, that want of synchronous and appropriate action of each part of the vocal mechanism concerned in speech, is essentially and fundamentally the cause of stammering. The most common cases of stammering occur, when persons attempt to articulate the desired sounds without putting the glottis into vibratory action; and, therefore, in order to remove

this kind of impediment, the treatment consists in instructing and exercising the patient in the method of using the vocal apparatus properly. To effect this purpose, it is necessary to direct the patient to vocalize the breath so as to utter a continuous sound, as by singing a note in music. This he should do, in the first place, without making any attempt to articulate a syllable; and then, on repeating the same sound, should endeavour to articulate the word required. This he will be enabled to do immediately, if, during the whole time that the attempt is made to pronounce the articulate sounds, the glottis is kept in action by the vocalization of the air issuing from the lungs, and the articulating apparatus performs the necessary actions. In this manner the patient will be enabled to overcome, on the first trial, some of the difficulties of articulating at will.

In confirmation of the foregoing statement, it is a notorious fact that such persons, if they happen to be vocalists, can articulate with fluency during the act of singing, and hence we need no stronger proof of the defect having its origin in functional causes alone, and not in any malformation of the organs of voice. The painful configurations, and spasmodic contortions of the mouth and face are produced, in consequence of the stammerer attempting to articulate with unvocalized breath: these have been ascribed to a choreal state of the vocal organs; they may, however, be often traced

directly to an imperfect combination, rather than to a want of voluntary control over them. By pursuing the plan above described, no difficulty is experienced in making the worst stammerer utter whole sentences uninterruptedly; and, after a few lessons, the most illiterate persons may be taught how to articulate with facility.

Cases have been described in which the motions of the tongue are said to have been restricted by the genio-hyo-glossi muscles; and it has been asserted by Amussat, and others, that the division of the genio-glossi portions has been attended with apparent relief. There is most probably some fallacy in these views, and the power of articulation should always be tested on the principles already described, before any attempt is made to relieve the defect by operating with the knife. When we reflect on the severity and gravity of the methods pursued by Dieffenbach for the relief of stammering; which consist either in the division of the muscles of the tongue at its root, cutting at the same time through the linguales, genio-hyo-glossi, and stylo-glossi muscles, with their bloodvessels, and nerves; or in cutting a transverse wedge-shaped slice out of the dorsum of the tongue, we may easily conceive the danger of hemorrhage, and sloughing, which must result from such operations. It appears, indeed, to be wholly unjustifiable for surgeons thus to inflict wounds, and mutilate organs, upon mere hypothesis,

more especially when the practice is at variance with the physiology of the parts concerned in the defects of speech intended to be relieved.

Cases arising merely from temporary derangement of the nervous system, such as over-excited emotion, which may be indicated by the patient being at one time able, and at another time unable, to articulate fluently, have strangely enough been supposed capable of cure by the extirpation of some portions of the vocal organs. Effects such as these may be easily explained from our knowledge of the effects produced on the voluntary muscles, by any sudden impulse given to the mind. It is well known that many astonishing acts are occasionally performed by the voluntary muscles under excitement, of which they are incapable at other times. It is not, then, surprising that the extirpation of portions of the tongue, tonsils, uvula, and velum, should produce such a degree of mental excitement as to control for a time the vocal mechanism; but, after the excitement of the operation has passed away, the unhappy sufferers relapse into their former state of imperfect articulation.

There is, however, another class of cases of common occurrence, to which neither the principle of vocalization during articulation, nor of an impulse given to the mind, whether through surgical operation or otherwise, will apply. Reference is now made to those cases in which the mechanism has never been trained to execute the combined actions necessary

for the production of certain elementary sounds. These cases may arise from a variety of causes, such as defective hearing, imperfect imitation, or even inattention. We know that the power of speech depends entirely upon the sense of hearing, since those who are born deaf are likewise dumb. But there are also many persons whose hearing is good, but who, from some defect in their powers of imitation, or from a want of proper attention, are unable to articulate certain letters or words.

On careful investigation, it will be found that the interruptions of vocalized breath in stammering may take place by the irregular actions of four different sets of organs: 1st. By the closing of the valve of the glottis; 2ndly. By the closing of the isthmus of the fauces; 3rdly. By the dorsum of the tongue being brought into contact with the palate; 4thly. By the closing of the lips and posterior nares. In the first case, the air is condensed in the trachea; in the second, the same effect takes place in the vocal tube, posteriorly to the isthmus of the fauces. When the glottis is irregularly closed during speech, the articulation of all the vocal sounds is prevented. A prolonged closing of the isthmus of the fauces necessarily obstructs the pronunciation of those letters and syllables which begin with gutturals, as *king*, *good*, &c. The involuntary or misdirected action of the tongue affects the series of lingua-dentals, lingua-palatals, and lingua-palato-nasals, and therefore words and syllables beginning

with those letters. That of the lips not only affects the labials, but may likewise impair the pronunciation of all the other letters. By listening to the manner in which the breath is suppressed, or suffered to escape, the ear of any experienced person may easily detect, without ocular inspection, whether it is the valve of the glottis, or of the isthmus of the fauces, which is instrumental in producing the interruption. The same observation will enable him to discriminate the effect produced, when the sounding column of air is stopped by the tip of the tongue. When the lips are the cause of the interruption, we have ocular demonstration to assist us in distinguishing the organs which are instrumental in causing the defect.

The irregular actions of the vocal mechanism just described are very frequently found to be owing to derangements of the nervous system, such as excited emotions. There are, indeed, few persons whose emotions on some subjects do not disturb the equilibrium of the nervous force to such an extent as to interfere materially with the normal exercise of the intellectual, respiratory, and vocal functions. The extraordinary derangement of nervous force displayed in excited emotions, the control exercised by these emotions over the rest of the nervous system, and their influence on the living being in health and disease, render them a subject alike important to the physiologist, and the pathologist. When the force which produces emotion is in excess, its ten-

dency is to paralyze the intellectual, and to disturb the vital functions, in such a manner as to induce organic disease, and in some cases even sudden death.

Whatever may be the nature or cause of the changes in the brain which correspond to the several kinds of emotion, the changes themselves are, in the opinion of Müller, propagated from the brain to the medulla oblongata; the latter in its turn influencing the action of the respiratory muscles through the medium of the corresponding nerves, and affecting in an especial manner the motor nerves and muscles of the face. Dr. Marshall Hall has brought forward many facts which tend to show that the emotions are seated in the medulla oblongata, or at least in some part of the nervous centre below the cerebral hemispheres; and he has pointed out their influence on the paralyzed side in hemiplegia, when that of the brain is cut off.

The influence of the passions is transmitted by the motor nerves, producing effects corresponding to the nature of the passion, and may either increase, diminish, or even paralyze the action of remote parts during a longer or shorter period. It is observed, however, that similar phenomena may be produced by different emotions, and that weeping, sighing, and sobbing may alike follow intense joy, anger, or pain. Anxiety, fear, and terror depress the action of the brain and spinal cord, and the legs in consequence tremble and are scarcely able to

support the body; the look is vacant, and devoid of expression; the functions of the respiratory organs also are deranged, and cannot be controlled by the will.

In dealing with this question, then, we are restricted to the study of the phenomena themselves, and to the circumstances which experience shows will tend to restore to its normal intensity the force, which is either excessive or deficient in some portions of the nervous system.

The phenomena of the animal and vital functions show that the whole of the nervous matter is influenced by a force, which is in constant action in the automatic, and in occasional action in the voluntary functions; that this force is limited in amount; and that, consequently, if an undue portion of it be expended upon any particular function, the other functions, or at least some of them, will of necessity be imperfectly performed. The connexion between the formation of ideas and the various emotions is well established, and the latter are placed in some degree under the control of the will; indeed, were not the emotions regulated by the intellectual power, man would not occupy the lofty position which he now holds in relation to the lower animals, but would be the prey of his own passions. That volition has a decided control over the emotions, especially those which are exhibited through the agency of the voluntary muscles, is unquestionable; but its control over the organic system is very much restricted;

and on the stomach, heart, and other organs supplied by the ganglionic nerves, the emotions act almost independently of volition, except under extraordinary efforts of the mind. It is not surprising, therefore, that such functions should have a great influence over the voice, speech, and respiration. The emotions which arise in the system of a person, when he is about to address an audience, are often so overpowering, that the voice loses its natural volume, becomes tremulous, and sometimes inaudible, the respiratory functions are irregular, the flow of ideas is impeded, and the articulating organs perform their office so imperfectly, that he who is generally ready and fluent in conversation, hesitates, stammers, and cannot utter a single connected sentence. Now, if persons who at other times have a perfectly voluntary control over the organs of voice and speech, partially lose it under the circumstances just mentioned, *à fortiori* those who have at all times an imperfect control over their articulation will, in similar states of feeling, find their powers paralyzed, and their speech more than usually defective.

It is desirable now to explain the conditions necessary to be observed in order that the control over speech, when acquired, may be maintained; since without such knowledge the duration of this power is uncertain, and the patient is liable to relapse. In most of the cases which have come under the author's observation, patients who had attained the habit of

speaking very fluently when not over-excited, relapsed the moment anything occurred which produced emotions of fear or anxiety. In order to counteract this tendency, it is necessary, as soon as the power to articulate correctly in private is acquired, to accustom the patient to read and speak daily before strangers. Under this discipline, continued for a longer or a shorter time, the emotions gradually subside, and the power of volition over them is strengthened, and it is not until the patient has been thus thoroughly exercised, that any dependence can be placed on his retaining what he has acquired.

In many persons the intellectual and vocal organs are capable of acting very well separately, as for instance in the solution of a difficult problem by the former, and in ordinary reading aloud by the latter; but the same persons often fail in combining these functions, as is evident in those who, without being under the influence of fear, nevertheless cannot express their ideas clearly in public. This defect in the power of association generally commences early in life, and is chiefly owing to the imperfect training of the vocal and mental functions in our schools. It must be remembered that, not one of the series of actions under consideration is automatic, but that all are dependent on volition, exercised almost simultaneously, through the instrumentality of a multitude of organs. The working of such exquisite machinery cannot be acquired

without much practice; and when, on investigation, we find that such a variety of successive physical changes is necessary for the production and vocal expression of a single idea, it is rather a matter of astonishment that the generality of persons speak so well as they do. It is, moreover, an object of considerable importance to lessen the excitability of patients labouring under these nervous affections, by appropriate medical treatment, which may tend to aid the practitioner in bringing the patient into such a state as will enable him to exercise a voluntary control over the mental and vocal functions simultaneously.

It might be imagined by some persons that this is merely a psychological inquiry, and beyond the range of therapeutical studies; but, on mature reflection, it will be found in this, as in other cases, that those who exclude from their view the mental states of patients, and restrict themselves to the consideration of their bodily conditions, neglect the operation of an agent which controls more or less all the functions of the system.

The time occupied in the utterance of a series of monosyllables varies considerably in different individuals. When words are set to music, the time of each syllable is regulated by a definite scale; but, in ordinary speaking, the choice of the time is arbitrary, and left to the taste and ability of the speaker. Nervous and irritable persons are often

betrayed into a hurried mode of articulation; and, involuntarily attempting to blend the sound of one monosyllable with the succeeding one, necessarily stammer in the endeavour to accomplish a physical impossibility. For the improvement of such persons, it is found useful to fix their attention on the oscillations of the pendulum of a metronome, and to cause them to pronounce a syllable at each vibration. When the beat of the latter is from sixty to eighty-four in a minute, it will be sufficiently rapid for practice. Steel observes that "good speakers do not pronounce above three syllables in a second, and generally two and a half, taking in the necessary pauses."*

Where the involuntary actions of the voluntary muscles which close the vocal tube, occur only under occasional states of mental excitement, the treatment consists in establishing a healthy nervous control over the vocal organs. It is now well ascertained that the ordinary respiratory movements belong to a series of automatic actions connected with the vital functions, while the production of voice and speech belongs to the voluntary system, and, of course, to the animal functions. Of the reflex and automatic nature of the respiratory movements we have conclusive proofs, from the circumstance that in some animals they continue in action on the application of stimuli,

* Prosodia Rationalis, p. 49. London, 1779.

even after the removal of the cerebrum and cerebellum, and also continue during sleep when volition is partly suspended. On the other hand, vocalization and articulate speech are purely voluntary actions, which can be excited and suspended at pleasure. There is, however, in man, a mutual relation subsisting between the voluntary and involuntary systems, owing to which the reflex action may be disturbed by volition, and its rhythm deranged. The respiratory movements may thus be accelerated or retarded by different states of mental excitement; and, if this interference with the reflex action is often repeated, and the periods of its rhythm prolonged, the latter may be partially destroyed, and a voluntary act may then become necessary to replace the ordinary reflex movement of inspiration. Similar derangement occurs from the interference of voluntary action in suppressing the expulsion of the fæces and urine, after the spontaneous impulse for that purpose has taken place. Under these circumstances, the sphincters become spasmodically closed, and the intestines and bladder refuse to discharge their contents. Hence we infer, that the action and reaction naturally subsisting between the vital and physical forces of the animal economy concur only whilst they are uninterrupted; but if by the interference of volition they are prevented from taking place, the reflex action is either partially or totally suspended, for a longer or shorter period. Presuming the principles above stated to be

established as the results of experience, we may proceed to apply them to the subject under consideration. Many public speakers, such as clergymen, barristers, &c., when addressing large assemblies of people, are obliged to produce loud and prolonged sounds, under the influence of which the mind becomes more excited, and the chest is exhausted to a greater degree than occurs in ordinary conversation. The prolongation of the inspiratory movement thus occasioned tends to cause an engorgement of the lungs, and of the right cavities of the heart, impeding the arterialization and free circulation of the blood. Hence arises a tendency to dilatation of the heart, and the patient feels a sensation of weight and oppression in that organ, causing nervous depression, and anxiety of mind. The administration of stimulants tends to increase these symptoms, by increasing the engorgement of the lungs and heart, which continues as long as the number and force of the respiratory movements do not keep pace with the increased velocity of the blood produced by the stimulants. When a person addressing an audience endeavours, under the excitement of the moment, to finish a sentence in the same breath, the chest is often greatly exhausted, and no attempt is made to replenish it with air until the reflex system becomes so excited as to render an act of inspiration absolutely compulsive. The voluntary control being thus overpowered, a rapid inspiration is attempted;

but, the thyro-arytenoid ligaments being in a vocalizing position, the air cannot rush into the chest through the chink of the glottis as fast as is requisite, and in the first moment of the inspiratory act a croup-like sound is emitted. Whilst this is going on, the expansion of the chest proceeding faster than the intromission of air, a partial vacuum in the thorax would be produced, were it not prevented by a compensating, though unsteady movement of the diaphragm. If these interferences between the voluntary and reflex systems be repeated periodically at short intervals, as is often the case with clergymen, and other public speakers, the derangement of the functions becomes so aggravated, that the voluntary control over vocalization and the natural rhythm of the respiratory movements is lost, and the invalid is obliged, for a longer or shorter time, to abandon public speaking. These disturbances very commonly arise from the duties of clergymen, who are most usually the victims of these functional maladies. It is not uncommon for those who are celebrated for their command of language and eloquence to suffer in this manner, to utter a croup-like inspiratory sound in speaking, and finally to lose voluntary control over their vocal organs. In order to show the practical application of these general principles, I shall now relate one of several cases which have come under my notice. A clergyman of delicate constitution, and nervous temperament, with inactive

digestive organs, was seized, about twelve years since, with an attack of hemiplegia, which paralyzed the muscles on the right side of the head and face, including those of the eyeball, but he retained control over the functions of deglutition, and vocalization, and after the lapse of several years, the muscles on the paralyzed side resumed their normal action. The treatment to which he chiefly ascribed his improvement was electricity, administered by means of an electro-magnetic machine. At this period, his voice retained both its power and quality. About three years ago, however, he began to lose a portion of voluntary control over the vocal organs. He found that, after having exhausted his chest, he made a croup-like sound on drawing in the breath. This was no doubt owing to the ligaments of the glottis being at the time in the vocalizing position, and consequently vibrating during forcible inspiration. The diminished aperture of the rima glottidis prevented the chest from being fully replenished with air during the inspiratory process; consequently, when the patient had exhausted his chest, he found that he was obliged to stop suddenly in the middle of a sentence, and could not utter another syllable until the lapse of some seconds, when the balance between the action of the glottis and of the respiratory muscles was restored. On again proceeding to read, the same circumstance recurred, so that he was obliged to abandon for a time his clerical duties. The normal action of the

reflex system presiding over inspiration was in this case so impaired, that the ordinary stimulus to draw in the breath did not produce this result, and the patient, being unconscious of what was going on, continued to exhaust his chest until the stimulus arising from its physical condition was such as to render an act of inspiration imperatively necessary. After a time, the action of the vocal apparatus became so uncertain, weak, and tremulous, that he was unable to sustain his voice even in ordinary conversation. The circulation of the blood was carried on languidly, and with a sense of weight in the region of the heart, which he supposed to be diseased, or dilated.

Under these circumstances, he consulted several eminent medical and surgical practitioners in London, by whose advice he had recourse to tonics, sedatives, counter-irritants, and other remedies, which produced no relief. A galvanic current, daily passed through the larynx, seemed however to produce some advantage, and the voice acquired temporary power; but these effects were very transient. The patient had once or twice tried the compound decoction of sarsaparilla, which very materially diminished the power of the voice; at least, after repeated trials, the result was always a partial loss of voice. In the treatment of this case, after ascertaining the degree of control which the patient still retained over the muscles of inspiration, I directed him to fill his chest before attempting

to speak. This was performed with some difficulty, and the inspiratory process was languid and irregular; a state which seemed to be occasioned by some peculiar conditions of the diaphragm and glottis. After a little practice, however, the voice, which was at first weak and tremulous, could be sounded in a full strong tone; but it was necessary at intervals to remind the patient that it was time to inspire, or the chest would otherwise become exhausted. Some remedies calculated to restore the tone of the digestive organs, and to relieve nervous excitement were ordered; and he was directed to practise the periodic rhythmical actions between the respiratory and vocal functions. He was advised to abstain from his clerical duties until his power over the disordered functions was restored by exercise. It was, however, found very difficult for the patient to practise this exercise without assistance, inasmuch as he was totally unconscious of the degree of exhaustion which the chest had undergone, and did not perceive the proper moment for refilling it by inspiration, unless his attention were directed to it by another person.

There was considerable difficulty in forming a correct diagnosis of the nature of this case, since the paralysis which preceded the derangement of the respiratory and vocal functions might have been supposed to have had a share in producing the affection. It must be apparent that the restora-

tion of this patient could never have been effected by any of the remedies found in the pharmacopœias; and it is therefore not surprising that the tonics, counter-irritants, and sedatives employed, did not produce the results anticipated.

It is obvious that cases which present symptoms like those just related, must be treated according to the pathological state presented in each case; but this cannot be accomplished unless we are previously enabled to form a correct diagnosis of the cause of the symptoms.

The most frequent cause of stammering is the imperfect education or training of the organs of articulation, and a deficiency in that sympathetic association which ought to subsist between the articulating and vocalizing organs. The various and complex modifications of the organs of articulation are acquired only by long and attentive observation, the healthy action of the ear being fundamentally necessary for this purpose; and even although its functions may be healthy, experience often proves how difficult it is for some persons to imitate the isochronous pitch of the most simple sound, which many indeed can never accomplish. In like manner, when a person whose articulation is perfect hears a strange word pronounced, as, for example, a word in a foreign language, he is often obliged to make many attempts before he can repeat it. In the Turkish, Arabic, and Russian languages, words might

easily be selected which few Englishmen could imitate without long and continued practice. Is it not, therefore, reasonable to expect that stammering persons, whose organs of articulation have been for many years imperfectly or improperly applied, will require similar efforts to overcome the defect, even after they have been properly instructed how to do so. The configurations of the mouth and pharynx in speech being numerous and complex, the slight changes which modify the sound cannot be very readily explained to the stammerer: his ear must catch all the modifications of sound which constitute articulate language; but it is only by the regulated exercise of the organs of articulation that he can expect to be able to imitate them; and it is owing to the imperfect manner in which this has been performed, that stammering in the greater number of cases arises.*

Drs. Arnold, Müller, and Schulthess agree in considering the cause of stammering to be a spasmodic affection of the glottis producing a momentary closure of the rima glottidis. Müller, however, remarks very properly, that "it must be remembered as a principle, that the momentary

* No person who has once thoroughly learned to articulate properly can easily stammer while the glottis is maintained in a state of vibration. In the perfect mutes, however, as the vibrations are suppressed, it is necessary to preserve the thyro-arytenoid ligaments in the vocalizing position, in order to begin the intonation of the voice as soon as the mute is perfected.

spasm depends *entirely on a morbid association of the movements of the muscles of the larynx with the movements of articulation.*" We here observe that this definition is at variance with the idea of spasm of the glottis; for irregular voluntary association of actions does not constitute spasm, and the repetition of *ha-ha-ha-have*, is the voluntary attempt to overcome the difficulty, as likewise in the examples of *g-g-g*, *l-l-l*, *t-t-t*, and *b-b-b*, in which the impediment is caused by the organs articulating those letters, the glottis remaining mute, but not spasmodically closed. In fact, Schulthess is quite correct in saying that the repetition of the same sound in stammering is merely a series of attempts to overcome the difficulty, as *l-l-l-laughing*, *t-t-t-t-take*, *b-b-b-better*.

In sounding the sibilant S, many persons do not adjust the position of the tongue behind the teeth, so as to produce the clear hissing quality belonging to this letter; others place the tongue nearly as in TH, which is the cause of what is termed *lisping.* A great number of individuals pass through life with this defect; which is nevertheless capable of being very easily removed, by a little attention to the difference between the actions of the tongue, teeth, and breath, in S and TH respectively.

Those who are unable to produce the sound of R, have a difficulty in effecting the quick, vibratory motion of the tip of the tongue against the palate, and usually substitute the sound of L, which is

easier. A gentleman at the Irish bar, who laboured under this defect, consulted the author, to whom he stated that the defect had harassed him exceedingly, and injured him in his profession. He had made a tour in Germany, and had recently arrived from Rotterdam, but the attempt to pronounce the name of that place was almost unintelligible. After three or four consultations, however, during which the normal actions were explained to him, he acquired the power of articulating the letter R very correctly.

According to the researches of MM. Bennati, and Gerdy, the velum and uvula are chiefly instrumental in modulating the voice. In a memoir read before the Royal Academy of Sciences of Paris, the former has described and figured the positions and movements of the velum and uvula, coincident with the changes of pitch and modulation in singing. Although generally concurring in the views of these distinguished physiologists on the points above mentioned, it is proper here to state that the author objects to their hypothesis respecting the production of the falsetto. It is, however, by no means a matter of so much indifference as many persons appear to suppose, whether we have, or have not, such parts appended to the vocal organs as the tonsils, velum, and uvula. With regard to the tonsils, Bennati relates two cases, one of M. le Comte de Fedrigotti, who suffered, subsequently to an attack of acute nervous fever, from an enlarge-

ment of the tonsils, which was supposed to injure his voice. Two-thirds of them were therefore extirpated, and the effect produced was, that although the tenor register of his voice was improved, and the compass augmented by two notes, *he lost four notes of the falsetto register.* In the second case (that of M. Carcelli), the tonsils having been enlarged by chronic inflammation, the falsetto acquired an increased range of *five notes!* Gerdy also mentions a case, in which the whole pitch of the voice became more acute after the extirpation of the tonsils. Reference has been made to the preceding cases to show that, in singers at least, the tonsils are organs of some importance. The defective pronunciation of certain words, or the inability to sound certain letters, may, however, exist permanently in some individuals, without stammering, and may arise either from some malformation of the vocal organs, or from a misapplication of some portion of them.

In training the voice on the principle above proposed (see page 50), it is manifest that the duration of the interval between the pronunciation of each syllable will be inversely proportional to the power or control of the individual over the muscles of articulation, and *vice versâ.* In those who have very great difficulty in applying the principle, the interval must be long. The maintenance of a continued sound during speech, is not so difficult or so conspicuous as many persons may imagine. The

Parisians of the higher class most commonly speak with a continued sound, yet the tone of the voice is so modulated, as to render the effect but little different from the ordinary English mode of speaking, in which the tones are broken by brief intervals of silence between the words. Those who stammer in consequence of malformation, or disease of the organs of articulation, do not come within the range of this principle, and may possibly present fit cases for surgical treatment; but it is manifest that the indiscriminate application of the knife to healthy structures is unjustifiable, and irrational. When the horizontal laminæ of the palate bones do not meet, and the posterior nares are imperfect, a defect of speech is produced altogether different from stammering. The pronunciation of the letters called *mutes* is accompanied by a nasal drone, and that of other letters and syllables is incorrect; but this kind of imperfect articulation may be easily relieved by the introduction of an artificial palate.

A case illustrative of the functions of the tongue in articulation, is recorded in the Transactions of the Royal Society for 1776.

Margaret Cutting had lost the apex and body of the tongue by disease, but nevertheless continued to articulate all the letters of the alphabet; those which required the apex, such as *d*, *l*, *n*, *r*, *t*, were produced by the action of the under lip against the upper teeth; the latter, however, must have been very imperfectly performed. The influence of

wounds of the tongue on articulation presents some very curious results, especially when they have been inflicted at an early age. The following cases were brought under the author's notice during the autumn of last year. Two young twin brothers presented themselves for examination to one of the metropolitan societies as missionaries; but their mode of articulation was so exceedingly defective and peculiar, that they were supposed to have some irremediable malformation of the vocal organs; but, before coming to a decision, the Society desired the author's opinion to be taken respecting them. On investigation, he found their intonation extremely nasal, similar to that in cleft palate, and that they could not pronounce many of the letters of the alphabet, but supplied their places with other sounds; so that their language was very disagreeable, and sometimes scarcely intelligible. The fauces, palate, and other vocal organs were, however, found to be in a normal state. On further search after the cause of the defective articulation, it was ascertained that one of them, when a little boy, had wounded his tongue so severely, that he was unable to use it in ordinary speech; and that, in order to make himself understood, he substituted a series of nasal sounds which did not require the wounded tongue to be put in motion, and in this way acquired the habit of articulating in the manner already described. The twin brother imitated the one thus affected, and, in consequence of their

being educated together, acquired the same mode of articulation. On explaining to them the nature of the normal actions to be acquired, they immediately began to practise them; and, after the second interview, ceased to consult the author, being confident of their ability to master their defects.

In another case, a gentleman called upon the author to request his opinion respecting the best kind of artificial palate for a friend; but was informed that, before any opinion could be given, it was necessary to see the patient, who shortly after presented himself, and spoke in a tone like that of a person with a divided palate. On looking, however, into his mouth, the vocal organs were found, as in the former cases, to be sound. On inquiry, he stated that when young he fell and cut his tongue, and from that time he had spoken very imperfectly, failing in all the sounds which required the use of the tip of the tongue, as well as in the letters *s*, *sh*, *ch*, &c. The cause and method of cure of his defective articulation were explained to him; and, after three or four visits, he wrote to say that he was able to speak correctly, and did not require further aid.

These cases are interesting as showing that when the actions of the organs of articulation are once deranged, they will require for their restoration a treatment founded on physiological principles.

Members of parliament, barristers, clergymen, and others, required by their professional duties

to exercise the voice for lengthened periods, often suffer from enlargement of the tonsils, relaxation of the pharynx, and irritation of the larynx. Public singers, also, are liable to the same kind of irritation, sometimes even giving rise to the rupture of a bloodvessel. In addressing large audiences, the room must necessarily be capacious, and the intensity of the voice must be proportionate. During these exercises of the vocal organs, the transit of the air to and from the lungs tends to carry away the moisture from the mucous membrane lining them; and, after speaking during a great length of time, a sense of dryness in the throat indicates the necessity of quiescence, or of a draught of water to restore the humidity. As soon as the mucous membrane is thus irritated, the tone of the subjacent fibrous tissues becomes relaxed, and the voice often either falters, or loses a portion of its power; the tonsils partake of the irritation of the surrounding tissues, and, like other glandular structures when irritated, become enlarged. In relaxed states of the system, the tonsils often acquire considerable volume; and under a frequent recurrence of the cause, as in the case of clergymen, there results a state of the tonsils and surrounding parts, commonly designated "clergyman's sore-throat." The early stage of these derangements is often neglected, and recourse is had to surgical advice only when the organs in question have already suffered considerable mischief. Under these cir-

cumstances, the patient should be enjoined to abstain for a time from clerical duties, to take such remedies as will restore the general tone of the system; and, if the application of escharotics, such as nitrate of silver, or nitric acid, fails to reduce the volume of the tonsils, recourse may be had to extirpation. In the early stage, the treatment may be of a more mild character, and will be attended with more satisfactory results. The most rational treatment is obviously the removal of the primary cause: for the treatment of effects, whilst the cause is suffered to continue in operation, cannot be expected to prove successful. The enlarged state of the tonsils in clergymen injures the quality and power of their voice, but it does not produce impediments of speech, as it ought to do, were the tonsils (as has been supposed) concerned in stammering. In singers, long-continued and excessive exercise of the vocal organs is often productive of protracted injury, more especially affecting the upper notes of the voice. Young females, endowed with great range of pitch, have, by excessive use, so relaxed the vocal mechanism, as not only to lose many notes of the scale, but also to impair the quality of their voice during the rest of their lives. The author has also been consulted by others suffering from an enlargement of the tonsils from the same cause. He has, at the present time, under treatment cases of this nature, occurring in young females between the ages of twelve and fifteen. It is therefore prudent

to recommend to very young vocalists, when beginning to train the voice during its development, to commence by exercises of limited duration. The uvula sometimes becomes relaxed by excessive efforts in singing, and then requires to be touched with nitrate of silver. In a case lately sent for the author's opinion by Mr. M'Whinnie, the person had a fine tenor voice of great range; but, from much exertion, the uvula became relaxed, and he lost the upper note of his voice. Bearing in mind the effects produced on the voice by excision of the tonsils, as described by Bennati, he recommended the lower third to be cut off, at the same time not pretending to predict the effect the excision would have on the voice. When, however, the author saw the patient a few days after the operation, he stated that he had recovered the lost note in his register, the quality being somewhat clearer. In other cases of professional singers, the author generally advises the use of caustic, rather than risk the effect of excision; inasmuch as, should the voice sustain injury by the operation, the prospects of the patient would be ruined.

Another example of derangement, resulting from excessive vocal exertion, may be worthy of notice. About five years ago, a lady endowed with a fine-toned soprano voice, whilst endeavouring to increase its power by forcible exercise, felt on one occasion a sudden pain, attended with a sensation as if

something had given way in the region of the crico-thyroid ligament. From that time, pain occurred in the same part whenever she attempted to sing. Shortly afterwards, the thyroid-gland began to enlarge, and has never since been entirely reduced. By applying tincture of iodine with a camel-hair brush every night, it appears, however, at length to be diminishing.

In conclusion, the principles here laid down for the treatment of impediments of speech have now been fully tested by the author; who, after considerable experience, has found that patients labouring under these defects have acquired a perfect control over the vocal organs, by applying the mode of treatment here proposed, after trying various other methods without any beneficial result.

It has been the custom of the author to furnish his patients with principles whereby they might always be enabled to recover themselves, should there exist any tendency to relapse. In this class of cases, however, as in many others, it is not uncommon to find persons too indifferent about the result to trouble themselves with the exercise of rules, after they had made themselves masters of them.

It must always be borne in mind, that we have not to deal with automatic functions, which, once set in healthy action, continue like the movements

of a watch; but with mechanism, the movements of which are placed under the control of the voluntary system, and subject to the irregular impulses of the intellectual processes.

THE END.

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